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Bibliography of In-House and Contract Reports, Supplement 17

Jean R. Diaz
E. James Books
Karen Carroll

September 1991

U.S. Army Corps of Engineers
Engineer Topographic Laboratories
Fort Belvoir, Virginia 22060-5546

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This is Supplement 17 to the ETL Bibliography of In-House and Contract Reports. This supplement provides author and title indexes, abstracts, and AD numbers for the 1989, 1990, and 1991 additions to the continuing bibliography. It also contains a complete title index designed to be used in conjunction with the 17 published bibliographies and refers to them by year and number.

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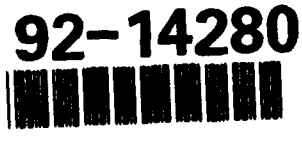

PREFACE

This is Supplement 17 to the report titled, "Bibliography of In-House and Contract Reports" AD-877 653L; Supplement 1, AD-890 066L; Supplement 2, AD-905 548L; Supplement 3, AD-B005 275L; Supplement 4, AD-B010 642L; Supplement 5, AD-B019 966L; Supplement 6, AD-055 468; Supplement 7, AD-A068 744; Supplement 8, AD-A084 111; Supplement 9, AD-A099 803; Supplement 10, AD-A113 006; Supplement 11, AD-A128 400; Supplement 12, AD-A141 778; Supplement 13, AD-A160 607; Supplement 14, AD-A173 750; Supplement 15, AD-A195 953; and Supplement 16, AD-A215 154. It is a continuing bibliography of reports prepared by and for the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia. This bibliography includes reports that were published from 1 October 1989 through 1 October 1991.

Reports with AD numbers can be purchased by Department of Defense agencies from the Defense Technical Information Center; other agencies and individuals can purchase copies from the National Technical Information Service, Springfield, Virginia 22161-2171. Reports with a "B" in the AD number are limited in distribution to U.S. Government agencies unless permission for release is granted from the controlling office. Reports are available on an interlibrary loan from the Scientific and Technical Information Center, U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia 22060-5546.

Colonel David F. Maune, EN, was Commander and Director, and Mr. Walter E. Boge was Technical Director of the Engineer Topographic Laboratories during the report preparation.

ETL-0496 AD B158 326L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM SEVENTH QUARTERLY REPORT March 1988

Edited by:
Gustav R. Hoyer

Martin Marietta Astronautics Group DACA76-84-C-0005

Keywords: Autonomous Land Vehicle, Image Understanding, Computer Vision, Unmanned Vehicles, Artificial Intelligence, Robotic Combat Vehicles, Robotics

During this quarter, we finalized our hardware and software testing and integration activities in preparation for the November 5, 1987 Autonomous Land Vehicle (ALV) demonstration. In hardware integration developments, we completed the installation and check out of the Warp systolic array processor and the Local Attitude Reference System (LARS). In software development activities, we finalized the integration of all software components that, in totality, comprise the 1987 ALV Computer Software Configuration Item (CSCI), which is, in Department of Defense software requirements specification terminology, the formal name for our 1987 computer software architecture. After fine-tuning the demonstration software configuration, we performed a series of pre-demonstration test runs to verify our readiness for the November 5 performance date. Following this, we placed the demonstration software CSCI under formal configuration management control.

ETL-0498 AD A240 746

HOURLY AND DAILY PRECIPITATION FREQUENCIES FOR THE UNITED STATES December 1988

Ruth L. Wexler

Keywords: Hourly Precipitation, Daily Precipitation, Short-Term Rainfall, Precipitation Models, Computer Programs

This report presents daily and hourly precipitation probabilities for an extensive network of stations throughout the United States, from special summaries of observations obtained over the decade 1951-1960. When data are in the format of cumulative percent frequency per precipitation rate, the daily and hourly distributions each form a fairly regular progression, per P/D or P/H, respectively (P = total precipitation, D = days, H = hours). The resultant models, in the form of succinct tables, graphs, or computer programs, provide a ready means for recovering the original observations, or estimating any selected precipitation rate for a wide spectrum of precipitation regimes in the United States, or elsewhere. The models, which serve as a check on data errors, or weather modification, also indicate to the engineer preferred areas for testing particular equipment. The methodology for the comparison among stations (or countries) of the actual short-term precipitation distributions, given only routine climatic data, should be highly useful for assessing more accurately a host of factors, as: soil moisture, trafficability, water supply crop yields, or possible malfunction of electronic equipment. The greatest advantage of the result is that they may be utilized for estimating short-term precipitation in data sparse localities.

ETL-0515 AD B158 274L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM PHASE II FIRST QUARTERLY SCIENTIFIC AND TECHNICAL REPORT August 1988

Edited by:
Gustav R. Hoyer

Martin Marietta I&CS

Defense Advanced Research Projects Agency DACA76-84-C-0005

Keywords: Autonomous Land Vehicle, Unmanned Vehicles, Expert Systems, Mobile Robots, Artificial Intelligence, Image Understanding, Computer Vision

Phase II of the program shifted away from annual system demonstrations to the use of the ALV as a "national testbed" for the purpose of hosting various experiments in autonomous land navigation technology. In hardware installation, integration and test activities, minor modifications were made to the vehicle's on-board computer hardware. We developed a new LNS navigation processor interface board, continued testing the Local Attitude Reference System (LARS), acquired a doppler radar ground speed sensor, developed a new architecture plan for real-time system development and sensor integration, introduced improved hardware documentation, and made mechanical improvements to the vehicle's mobility platform. In software developments, we continued to develop and test our prototype perception and reasoning (planning) software configuration for offroad navigation and finding the road from offroad. Our test activities on the ALV were primarily focused on documenting our vehicle hardware configuration; acceptance tests of the RF communications system; road checks of the vehicles handling characteristics following the installation of new automotive components; experimenting with our prototype perception and reasoning offroad software; validating our evolving concepts for offroad navigation; and perfecting our vehicle teleoperation hardware and software components and procedures. We also conducted several nighttime tests in preparation for future nighttime on and offroad experiments.

ETL-0526 AD B158 172L

THE AUTONOMOUS LAND VEHICLE (ALV) PROGRAM PHASE II SECOND QUARTERLY SCIENTIFIC AND TECHNICAL REPORT January 1989

Edited by:
Gustav R. Hoyer

Martin Marietta I&CS Defense Advanced Research Projects Agency DACA76-84-C-0005

Keywords: Autonomous Land Vehicle, Artificial Intelligence, Image Understanding, Unmanned Ground Vehicles, Mobile Robots, Machine Intelligence

During this quarter, our activities primarily focused on validating our evolving concepts for off-road navigation; continued experiments with our prototype off-road software architecture; correcting performance problems in our off-road software; and perfecting our vehicle teleoperation hardware and software components and procedures. In hardware installation and integration activities, minor modifications were made to the vehicle's on-board hardware. We installed a more capable video switch, modified the vehicle's control unit board, modified the Bendix LNS, and installed a new stereo camera system to support the Mars Rover program. In software developments, activities centered on the continued testing and refinement of our prototype perception and reasoning (planning) software configuration for off-road navigation and finding the road from off-road. We performed a number of software development tasks needed to support various hosted experiments on the ALV. We continued our research in video/range sensor fusion and inverse perspective algorithm comparison, developed a perception processing approach based on a 3-D vehicle model using the Warp, and developed a prototype multispectral image classification methodology using neural networks on the Warp. Our test activities concentrated on performance testing of the hardware installations made and supporting various experiments on the ALV testbed. These included our own off-road autonomous navigation tests, data collection for Advanced Decision Systems and Carnegie-Mellon University (CMU), and experiments by CMU and the Martin Marietta Mars Rover program. Our program staff representative made a coordination visit to the Jet Propulsion Laboratory (JPL) to determine their intentions and requirements regarding future experiments.

ETL-0545 AD A213 440

RESEARCH IN KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM
FINAL ANNUAL REPORT
August 1989

Editors:
R. Nevatia
K. Price

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W. Franzen
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G. Medioni
S. Peng

University of Southern California

DACA76-85-C-0009

Keywords: Autonomous Land Vehicle, Motion Analysis, Target Detection and Description, Knowledge-Based Vision

This report describes our research activities for the period of June 1, 1988 through May 31, 1989, and along with the previous annual reports it constitutes the "Final Technical Report." The researchers basic approach to detecting and tracking motion is to extract and match features, such as lines and regions, from a sequence and to generate motion estimates from these. Presented are: one report on spatio-temporal analysis for tracking edges through very closely spaced sequences; a report on matching edge-based contours using edges from multiple scales with low resolution guiding high resolution matches; and an analysis of estimating 3-D motion and structure of moving objects with uniform acceleration.

ETL-0546 AD A212 555

DEVELOPMENT OF AN INTEGRATED MOBILE ROBOT SYSTEM AT CARNEGIE MELLON UNIVERSITY
July 1989

Steven Shafer
William Whittaker

Carnegie Mellon University

DACA76-86-C-0019

Keywords: Strategic Computing, Machine Vision, Autonomous Land Vehicle

This report describes progress in development of an integrated mobile robot system at the Carnegie Mellon Robotics Institute from July 1987 to June 1988. The program includes a broad agenda of research in the development of mobile robot vehicles, focused on the NAVLAB computer-controlled van. In the year covered by this report, we addressed major issues in both hardware and software for autonomous mobile robots.

* Evolution of NAVLAB Vehicle. We built the NAVLAB mobile robot vehicle in our previous work under this contract, by outfitting a commercial truck chassis with computer-controlled drive and steering controls and a set of on-board computer workstations. The NAVLAB serves as a mobile navigation laboratory that allows researchers to interact intensively with the system during testing and execution. This year has seen a continued evolution and improvement of the NAVLAB mechanism, sensors, controller, and Virtual Vehicle interface to higher-level planning and perception software.

* Evolution of the CODGER Blackboard. Last year, as part of this research program, we designed and implemented the CODGER Blackboard system for robot perception and reasoning on a distributed collection of processors. This year, in response to our experience in using CODGER for mobile robot control, we have upgraded it to deal with geometric models and uncertainty in perception and map data.

* Experiments With the Driving Pipeline. To control the NAVLAB and Terregator mobile robot vehicles, we developed the Driving Pipeline architecture last year for coordinating road following, obstacle avoidance, and vehicle motion control. In our ongoing research, we have performed numerous experiments with this system that demonstrates its value.

This hardware and software is the basis for the New Generation System (NGS) for robot vision and navigation, which integrates many independent technologies to produce an integrated mobile robot system.

ETL-0547 AD B141 402L

FEASIBILITY OF A REDUCED POWER-CONSUMPTION MAGNETOMETER FOR USE IN A DIGICOMP LENSATIC COMPASS

August 1989

George Hsu
Timothy Joel Hawks

Precision Navigation Incorporated

DACA72-88-C-0001

Keywords: DIGICOMP, Digital Compass

This report summarizes the Small Business Innovative Research (SBIR) Phase I research effort performed by Precision Navigation, Incorporated, for the U.S. Army Engineer Topographic Laboratories' DIGICOMP project. The feasibility of using Precision Navigation's proprietary magnetometer and clinometer technologies in a battery-powered, handheld, tilt-compensated digital compass replacement for the standard issue Army M2 compass has been successfully assessed. The magnetometer and clinometer technologies have proven to be low-power and accurate enough for use in a battery-powered, tilt-compensated compass system. During the research effort, the magnetometer sensor was extensively characterized and optimized for linearity, zero-drift, and power consumption.

ETL-0548 AD A214 481

VISION-BASED NAVIGATION AND PARALLEL COMPUTING
FIRST ANNUAL REPORT
August 1989

Larry S. Davis
Daniel DeMenthon
Thor Bestul
David Harwood

University of Maryland

DACA76-88-C-0008

Keywords: Autonomous Navigation, Computer Vision, Parallel Processing, Search

This report describes r . ·rch performed during the period May 1988-May 1989 under DARPA support. The report contains discussion of four main topics:

1. On-going research on visual navigation, focusing on a system named RAMBO, for the study of robots acting on moving bodies.

2. Development and implementation of parallel algorithms for image processing and computer vision on the Connection Machine and the Butterfly.

3. Development of parallel heuristic search algorithms on the Butterfly that have linear speedup properties over a wide range of problem sizes and machine sizes.

4. Development of Connection Machine algorithms for matrix operations that are key computational steps in many image processing and computer vision algorithms.

This research has resulted in twelve technical reports, and several publications in conferences and workshops.

ETL-0549 **AD A213 172**

DYNAMIC IMAGE INTERPRETATION FOR AUTONOMOUS VEHICLE NAVIGATION
FINAL REPORT
August 1989

Edward M. Riseman
Allen R. Hanson

University of Massachusetts

DACA76-85-C-0008

Keywords: Scene Interpretation, Spatial Reasoning, Sensor Motion

This report presents the results of the Dynamic Image Interpretation for the Autonomous Vehicle Navigation project for the time period February 26, 1985 through July 12, 1989. The purpose of the project is to develop algorithms and tools to enable a robotic ground vehicle to navigate autonomously through realistic landscapes. In this final annual report, we summarize our accomplishments in constructing robust algorithms used for vehicle navigation as well as tools that have been developed to more efficiently utilized these algorithms.

ETL-0550 **AD A215 154**

BIBLIOGRAPHY OF IN-HOUSE AND CONTRACT REPORTS
SUPPLEMENT 16
October 1989

Annemarie Black
E. James Books
Karen Carroll

Keywords: Bibliography, Scientific Reports

This is Supplement 16 to the ETL *Bibliography of In-House and Contract Reports*. This supplement provides author and title indexes, abstracts, and AD numbers for the 1987, 1988 and 1989 additions to the continuing bibliography. It also contains a complete title index designed to be used in conjunction with the 16 published bibliographies and refers to them by year and number.

ETL-0551 AD B139 032L

DIGITAL MULTICOLOR RECORDERS AND SCANNER THE TECHNOLOGY AND THE EQUIPMENT
December 1989

Stephen P. Hollandsworth
James W. Gladden

Keywords: Ink Jet, Laser Xerography, Electrostatic Recording, Thermal Transfer, Ion Deposition, Cycolor, Laser Photography, Halftone Dot, Photomultipliers, Photodiode, CCD's, Scanners

State-of-the-art, electronic, non-impact digital multicolor printers and recorders and scanners are reviewed in this technical note. A review of the various non-impact technologies (ink jet, laser xerography, electrostatic, thermal transfer, ion deposition, Cycolor, and laser color photography) are also presented. Also discussed are three types of radiant energy sensors (photomultipliers, photodiodes and CCD's) used for scanning full color imagery. In addition, halftone dot and continuous tone reproduction are explained and discussed.

ETL-0552 AD A216 516

EXPERT SYSTEM FOR MINEFIELD SITE PREDICTION — PHASE III
November 1989

Jonathan W. Doughty
Anne L. Downs

PAR Government Systems Corporation DACA72-86-C-0017

Keywords: Expert System, Minefield Site Prediction, GIS (Geographic Information System), Quadtree, Window System, Terrain Analysis, Minefield Doctrine

This report reviews the major system components of the Minefield Site Prediction Expert System (MSPES) and discusses enhancements made to the systems under Phase III of this contract. Phase III extended the knowledge base and significantly enhanced the operation of the system, both in the processing methods and analyst interaction with the system. Additional detailed descriptions of the MSPES and its architecture may be found in Phase I and Phase II Reports (ETL-0492 and ETL-0534). Phase III MSPES development continued on the Sun 3/160, using the Sun operating system and the X Window System graphics software package. A knowledge base was implemented which incorporates enemy location factors.

AN EVALUATION OF THE ERDAS IMAGE PROCESSING SYSTEM AND ITS POTENTIAL ROLE IN THE DIGITAL TOPOGRAPHIC SUPPORT SYSTEM
December 1989

John E. Anderson

Keywords: Image Processing, Remote Sensing, Geographic Information Systems (GIS), Multispectral Imagery

The evaluation of the Earth Resource Data Analysis System (ERDAS) image processing system was initiated as part of the softcopy exploitation work unit in the Data Base Development Branch of the Topographic Developments Laboratory at ETL. The work unit's main goal is to advise on the feasibility of integrating an image processing capability into the Digital Topographic Support System (DTSS). ERDAS is a commercially available image processing package which was selected as the test-bed for the evaluation. ERDAS was selected based upon three major criteria formulated at the beginning of the project: (1) Semi-powerful, user-friendly, interactive image processing capability, (2) Compatibility with the ARC/INFO geographic information system chosen by DTSS, and (3) VAX/VMS host compatibility. A fourth element, not cited, was cost.

The test-bed system consists of a 386/20 personal computer, Mitsubishi color monitor, polygon digitizing tablet, and ERDAS 7.3 version software running under a DOS 3.31 host. All image processing functions relevant to military terrain analysis were explored using acquired SPOT panchromatic and multi-spectral imagery over Fort Hood, Texas. These functions included image display, correction, spectral and spatial enhancement, roam/zoom, training field selection, supported supervised and unsupervised classification algorithms, and annotation and colorization of final images. Other features explored were special image algebraic routines including IHS to RGB, image warping or "geo-referencing", and 3-D image capabilities using elevation data.

The results of this evaluation have demonstrated that with few inexpensive upgrades to the DTSS PAWS configuration, an ERDAS or ERDAS-like image processing capability will greatly enhance the detail and accuracy of terrain and mobility products. This improvement will enable battlefield commanders to "see" the battlefield and to make more timely and accurate tactical decisions.

ETL-0554 AD A221 096

AUTOMATED SEGMENTATION AND EXTRACTION OF AREA TERRAIN FEATURES FROM RADAR IMAGERY
January 1990

Pi-Fuay Chen
Richard A. Hevenor

Keywords: Radar Image, Feature Extraction, Texture, Segmentation, Bayes Classifier, Region Growing, Edge Enhancement

An automated method for segmenting and extracting certain area terrain features from Synthetic Aperture Radar (SAR) imagery is presented. First, the input radar image is edge-enhanced by passing it through a Sobel operator in order to obtain the required edges for further processing. The unwanted noise, both from the original image source and from the edge operation, is reduced with a low-pass filter. The next step is a region growing process in which pixels of similar gray values in the filtered image are grouped and merged together. A method of selecting an optimum threshold that is essential for region growing is described. The pixels in the image after the region growing operation are further grouped into exactly four different categories, each with its own gray value. The four categories of pixels are then finally classified as water, fields, forests, or urban areas depending upon their gray values. A texture measurement scheme and a Bayes classifier are also incorporated into this effort for verifying the classification results.

ETL-0555 AD A220 093

FRACTURES IN ROCK: AN ANNOTATED BIBLIOGRAPHY
January 1990

Judy Ehlen

Keywords: Bibliography, Fractures, Data Analysis, Engineering, Rock Mechanics, Geology, Joint Propagation

This bibliography lists many papers concerned with fractures. Subjects addressed include: descriptive and quantitative characteristics of fractures, mechanisms of fracture initiation and propagation, methods for obtaining information on fractures in the field, and procedures for analyzing and interpreting the data in the laboratory. Papers on engineering applications are also included. Each entry is annotated and key words are given.

ETL-0556 AD A220 380

THREE APPROXIMATE METHODS FOR ESTIMATING THE BEST SUBSET OF GPS SATELLITES FOR SATELLITE POSITION CALCULATIONS
February 1990

Michael A. Crombie

Keywords: Spatial Position Accuracy, Global Positioning System (GPS), Position Dilution of Precision (PDOP)

Three methods approximating the best subset of four or five of N observable GPS satellites to be used for calculating spatial positions are evaluated. Position Dilution of Precision (PDOP) is used as the measure of effectiveness. Three GPS constellations are considered. The user spatial positions are taken from circular orbits ranging from 100 to 2400 nautical miles above the earth and from orbital inclinations ranging from 0 degrees to 90 degrees in 15 degree increments.

ETL-0557 AD B142 339L

KNOWLEDGE-BASED VISION TECHNIQUES TASK B: TERRAIN AND OBJECT MODELING RECOGNITION - EXECUTIVE SUMMARY
February 1990

Daryl T. Lawton, et. al.

Advanced Decision Systems **DACA76-85-C-0005**

Keywords: Model Based Vision Systems, Landmark Recognition, Perceptual Processing, Spatial Reasoning, Navigation, Autonomous Land Vehicle Systems, Image Understanding, Image Understanding Software Environments, Object-oriented Programming.

This report describes the Knowledge-Based Vision Techniques Task B: Terrain and Object Modeling Recognition project. Its primary objective has been to develop terrain and object autonomous land vehicle. This is fundamental for the eventual operation of concealed autonomous robots in complex outdoor environments. Our work has been organized into three major areas which correspond to the three volumes of this report. "Autonomous Systems for Navigation and Terrain Recognition" (Volume I) is concerned with terrain recognition and map building for an outdoor robot. This involves using limited a priori terrain maps to interpret imagery obtained from a vehicle and also how to build a usable representation of terrain from a freely moving vehicle with no a priori terrain information and also possessing limited recognition capabilities. "Tech Base Vision Research" (Volume II) involves basic research and development in several areas critical for eventual incorporation on an outdoor robot. This includes new approaches to perceptual processing, geometric modeling, inference, and the architecture of model-based vision systems. "Image Understanding Software Environments" (Volume III) concerns the software environments we have developed to support image understanding research and technical transfer to integrative applications such as the autonomous land vehicle project. This executive summary presents an overview and critical processing results for the work in all three volumes.

ETL-0558 AD B142 340L

KNOWLEDGE-BASED VISION TECHNIQUES TASK B: TERRAIN AND OBJECT MODELING RECOGNITION - VOLUME I: AUTONOMOUS SYSTEMS FOR NAVIGATION AND TERRAIN RECOGNITION

February 1990

Daryl T. Lawton, et. al.

Advanced Decision Systems

DACA76-85-C-0005

Keywords: Landmark Recognition, Qualitative Reasoning, Navigation, Spatial Representation, Model Based Vision Systems, Perceptual Grouping and Organization, Path Planning, Road Following, Object Recognition, Autonomous Land Vehicle Systems

This volume, "Autonomous Systems for Navigation and Terrain Recognition", presents a model-based vision system and a theory of spatial representation for navigation and terrain recognition by an autonomous land vehicle. This first involves techniques to generate and match predicted image structures from a priori terrain grid data. These predictions are used to direct perceptual processes to find structures such as road regions, horizon lines, terrain patch discontinuities, and anomalies using object models. This has been successfully applied to data from the Martin Marietta ALV Test Site. We then present a new theory of spatial representation called Qualitative Navigation. This allows for navigation using locally coupled scene descriptions called viewframes without use of a global coordinate system. An exploring robot can then build maps and navigate without a priori terrain information while utilizing limited object recognition capabilities and landmarks with potentially very large positional uncertainty. We extensively tested qualitative navigation in simulations of a mobile robot and developed techniques for viewframe extraction and matching. These techniques used a generic terrestrial scene model which includes several constraints on the formation of perceptual structures based upon the relative direction of gravity, the horizon line determined by the orientation to the immediate ground plane, and the projected egocentric directions from the observer on this plane.

ETL-0559 AD B142 341L

KNOWLEDGE-BASED VISION TECHNIQUES TASK B: TERRAIN AND OBJECT MODELING RECOGNITION - VOLUME II: TECH BASE VISION RESEARCH
February 1990

Daryl T. Lawton, et. al.

Advanced Decision Systems

DACA76-85-C-0005

Keywords: Segmentation, Perceptual Grouping and Organization, Image Understanding, Shape Representation, Generalized Cylinders, Bayesian Inference Nets, Model-Based Vision Systems

This volume, "Tech Base Vision Research", describes research in several areas of computer vision necessary for the development of autonomous vehicles and general machine vision systems. The volume is organized into the areas of (1) perceptual processing, (2) shape and object representations, and (3) prototype image understanding systems. The research in perceptual processing has been organized into three areas: perceptual organization of extracted image structures; segmentation using texture and color to form environmentally meaningful image regions; and multi-level stereo. The work in shape descriptions and object representations is part of an integrated attempt to combine generalized cylinder representations, which are used to describe complex objects, with perceptually based predictions and model-based inference for an integrated machine vision system. Two particular model-based vision systems have been developed using these representations. MOBI was created early in the project as a vision system for a robot which could successfully navigate and build maps, in real-time, of indoor environments consisting of walls, hallways, doors and rooms. It served as a catalyst to develop the SUCCESSOR system which combines all of the research described in this volume in modeling, perceptual organization, and inference in the framework of a general and extendible model based vision system.

ETL-0560 AD B142 342L

KNOWLEDGE-BASED VISION TECHNIQUES TASK B: TERRAIN AND OBJECT MODELING RECOGNITION - VOLUME III: IMAGE UNDERSTANDING SOFTWARE ENVIRONMENTS

February 1990

Daryl T. Lawton, et al.

Advanced Decision Systems

DACA76-85-C-0005

Keywords: Object-oriented Programming, Image Understanding Environments, Programming Languages, SYMBOLICS Lisp Machine, Apple Macintosh II Computer, Common Lisp Object System

This volume, "Image Understanding Software Environments," presents our work in developing software environments for image understanding research and applications. This work was initially motivated to support internal developments and to expedite technical transfer from ADS to the autonomous land vehicle system integrators. We have developed two different image understanding (IU) environments, Power Vision and View/Shark, and an exploratory prototype on the MAC II. The Power Vision environment was developed on the Symbolics LISP machine. It defines a basic architecture for IU software environments in terms of a small number of modular components and programming constructs which are built around objects commonly used in image understanding such as images, curves, regions, junctions, and groups. Algorithms are developed using these objects and a language called DEFIU for writing code and manipulating defined objects in terms of local neighborhood-level operations. Shark and View were developed to produce a machine independent image understanding environment. Shark is a CommonLISP/CLOS-based toolkit for building user interfaces. View is a CLOS-based set of image understanding constructs which is completely object-oriented and makes extensive use of the inheritance of CLOS to achieve abstraction and user-specific extendibility. We ported the CommonLISP-based IU environment onto the Apple Mac II series of personal computer workstations. *Note: This abstract was summarized for this bibliography.*

ETL-0561 AD A220 005

BUILT-UP AREA FEATURE EXTRACTION: FIRST YEAR REPORT February 1990

David M. McKeown, Jr.
Aviad Zlotnick

Carnegie Mellon University DACA72-87-C-0001

Keywords: Feature Extraction, Road Networks, Scene Interpretation, Built-up Area

This report describes research performed by the Digital Mapping Laboratory at Carnegie Mellon University on the analysis of aerial images of built-up areas during the first year of the Contract. This research can be divided into three major parts: (1) extracting road networks from images; (2) detecting and delineating buildings; and (3) basic research to support extraction of the above features. Previous work in large-scale spatial databases and in knowledge-based systems for scene interpretation is described. Research results performed under this Built-Up Area Feature Extraction contract are described. New research in road network extraction is discussed. New work in the use of structural analysis to hypothesize and verify buildings using monocular cues in complex imagery is also discussed. Finally, the current state of research including successes, failures, and goals for the second year continuation are described.

ETL-0562 AD A220 006

BUILT-UP AREA FEATURE EXTRACTION SECOND YEAR TECHNICAL PROGRESS REPORT February 1990

David M. McKeown, Jr.

Carnegie Mellon University DACA72-87-C-0001

Keywords: Feature Extraction, Scene Interpretation, Monocular Analysis, Built-up Area

This report describes research performed by the Digital Mapping Laboratory at Carnegie Mellon University on the analysis of aerial images of built-up areas during the second year of the Contract. During this year we have built on previous research, in road network extraction and in the detection and delineation of buildings using monocular analysis, accomplished during the first year of this research contract. We have expanded our research in monocular analysis to include the detailed analysis of shadows. Our shadow analysis research has resulted in three techniques for the interpretation of monocular imagery: building prediction, grouping of related building hypotheses, and building hypothesis verification. In addition, we have implemented a technique to acquire estimates of building heights using the length of cast shadows.

ETL-0563 AD A221 486

A PROGRAMMING ENVIRONMENT FOR PARALLEL VISION ALGORITHMS
FINAL TECHNICAL REPORT
April 1990

Christopher Brown

University of Rochester DACA76-85-C-0001

Keywords: Butterfly Computer, Parallel Processors, Computer Vision

Under this contract, the University of Rochester developed and disseminated papers, ideas, algorithms, analysis, software, applications, and implementations for parallel programming environments for computer vision and for vision applications. The work has been widely reported and highly influential. The most significant work centered on the Butterfly Parallel Processor, the MaxVideo pipelined parallel image processor, and the development of the real-time computer vision laboratory. For the Butterfly, the Psyche multi-model operating system was developed and the CONSUL autoparallelizing compiler was designed. Much basic and influential performance monitoring and debugging work was completed, resulting in working systems and novel algorithms. There was also significant research in systems and applications using other parallel architectures in the laboratory, such as the MaxVideo parallel pipelined image processor. The University of Rochester developed a heterogeneous parallel architecture involving pipelined and MIND parallelism and integrated it with a robot head.

ETL-0564 AD A221 871

PARALLEL ALGORITHMS FOR COMPUTER VISION
FINAL REPORT
April 1990

Tomaso Poggio

Massachusetts Institute of Technology DACA76-85-C-0010

Keywords: Computer Vision, Parallel Algorithms, Connection Machine

The main effort in this project has been directed towards the development of an integrated vision system - the Vision Machine - based on a parallel super computer. The core of the vision Machine is in fact a set of parallel algorithms for visual recognition and navigation in an unstructured environment. The present version of the Vision Machine has been demonstrated to process images in close to real time by: (1) computing first several low-level cues, such as edges, stereo disparity, optical flow, color and texture; (2) integrating them to extract a cartoon-like description of the scene in terms of the physical discontinuities of surfaces; and (3) using this cartoon in a recognition stage, based on parallel model matching. In addition to the development of the parallel algorithms, their implementation and testing, we have also done substantial work in several areas that are very closely related. These include: (1) design and fabrication of VLSI circuits to transfer some of the software algorithms to potentially cheap and fast hardware; (2) initial development of techniques to synthesize by learning vision algorithms; and (3) several projects involving autonomous navigation of small robots.

ETL-0565 AD A222 494

DEVELOPMENT OF AN INTEGRATED MOBILE ROBOT SYSTEM AT CARNEGIE MELLON UNIVERSITY DECEMBER 1989 FINAL REPORT May 1990

Steve Shafer
William Whittaker

Carnegie Mellon University DACA76-86-C-0019

Keywords: Mobile Robot System

This report describes progress in development of an integrated mobile robot system at the Robotics Institute at Carnegie Mellon University from July 1988 to December 1989. This research was sponsored by the Defense Advanced Research Projects Agency and monitored by the US Army Engineer Topographic Laboratories. This program pursued a broad agenda of research in the development of mobile robot vehicles, and focused on the NAVLAB computer-controlled van. In the period covered by this report, July 1988 to December 1989, we addressed major software issues for mobile robot vehicles:

* Evolution of the CODGER Blackboard and the Driving Pipeline Architecture
* Kinematic Path Planning for Wheeled Vehicles.

This software is central to the New Generation System (NGS) for robot vision and navigation, which combines many independent technologies to produce an integrated mobile robot system.

ETL-0566 AD A223 749

THE LANDFORMS OF GRANITIC ROCKS: AN ANNOTATED BIBLIOGRAPHY May 1990

Judy Ehlen

Keywords: Granite, Landforms, Process, Fractures, Weathering

This bibliography addresses the study of granite landforms throughout the world from a variety of different perspectives. It summarizes the content of more than 150 papers and books. The subjects addressed include theories of origin for the respective landforms, the weathering processes acting upon these landforms, and the composition, texture and structure (mainly jointing) of granitic rocks as they relate to landform development.

ETL-0567 AD A231 809

AUTOMATED EXTRACTION OF AIRPORT RUNWAY PATTERNS FROM RADAR IMAGERY
June 1990

Richard A. Hevenor
Pi-Fuay Chen

Keywords: Radar Image Feature Extraction, Computer Vision, Edge Enhancement, Connected Component

A method is presented to extract linear terrain features from Synthetic Aperture Radar imagery. An input radar image is smoothed with an edge-preserving smoothing operation. Edge detection is performed using a Sobel operator, and both the magnitude and directional images are computed. The edges are then strengthened using several iterations of a relaxation operation in which both the magnitude image and the directional image are updated with each iteration. The output of the relaxation operation is a binary edge image, which is then thinned. A connected components routine is then run in which two passes through the image are used to provide a unique label for each connected component. The connected components related only to the runway pattern are then extracted by computing certain properties of each component. A border-following algorithm is then used to follow only the outermost borders and give each of the pixels on an outermost border a maximum brightness value. A tracking algorithm is used to change the binary image array into a set of Freeman chain codes, which serve as the input to a line-forming routine that uses a standard polygon approximation algorithm. Experimental results on a real synthetic aperture radar image are presented.

ETL-0568 AD A222 675

AUTOMATIC LINE NETWORK EXTRACTION FROM AERIAL IMAGERY OF URBAN AREAS THROUGH KNOWLEDGE BASED IMAGE ANALYSIS
August 1989

Dr. H. Kazmierczak

Forschungsinstitut fur Informationsverarbeitung/Mustererkennung DAJA45-86-C-0049

Keywords: Image Processing, Structural Pattern Recognition, Blackboard Oriented Symbolic Processing, Knowledge Based Image Analysis, Image Understanding, Aerial Imagery, Urban Areas

Different methods for automatic detection of line objects applied to aerial images to extract streets from urban scenes are investigated. First, test results achieved from two existing methods of low level iconic image processing by stream following (line tracking) and structured parallel operations (image filtering, feature extraction) are given. Second, a medium level iconic image processing method developed for edge and area segmentation is described and results from image segmentation are presented symbolically. Then two preliminary approaches of high level symbolic processing by knowledge based blackboard oriented structure analysis are tested. One is originating with preprocessing by low level edge filtering, the other by medium level area segmentation. First results from the image understanding method for street network extraction are presented.

ETL-0569 **AD A238 937**

ETAK NAVIGATOR MODIFICATION FINAL REPORT
October 1990

Dr. Walter B. Zavoli
Gene E. Bloch

Etak, Inc. **DACA72-89-C-0007**

Keywords: Etak Navigator; Dead Reckoning; Electronic Map Display; Digital Map Display; Vehicle Navigation; Off-Road Navigation; UTM Conversion

Etak modified its land vehicle navigation device, the Navigator, for test and evaluation by the U.S. Army Engineer Topographic Laboratories. The Navigator is a low-cost off-the-shelf commercial device that exhibits accurate navigation along with a highly useful electronic map display. The device uses a combination of dead reckoning and map matching. As part of this contract, Etak found that it could create the necessary maps from DMA 1:50,000 scale source material, to an accuracy of 50 meters, and that the Navigator could input and display vehicle positions and waypoints in UTM coordinates. In almost 1400 km of drive testing in Fort Hood, Texas, the modified Navigator showed that as a dead-reckoning device it is accurate to 2% of distance traveled, while its map-matching algorithms gives the Navigator performance comparable to that of an absolute navigation device with an average error of 50 meters. This navigation device demonstrates useful performance for certain classes of Army vehicles. Other vehicles may require more robust and hence more costly devices. It is suggested that digital map displays like that of the Navigator could be a useful standard presentation device for all Army vehicle navigation.

ETL-0570 **AD B157 709L**

ASSISTANT FOR SCIENCE AND TECHNOLOGY ANALYSIS (ASTA)
August 1990

Thomas L. Adams

Advanced Decision Systems **DACA76-86-C-0010**

Keywords: Radar User Interface, Model-Based Reasoning

ASTA (Assistant for Science and Technology Analysis) provides analytical support for the S&T radar analyst. ASTA automates many of the typical calculations the analyst must perform, maintains consistency, integrates external databases and radar models and provides an easy to use graphical user interface. ASTA provides expert guidance in the analysis of radar systems, accepting values for system attributes, either directly from analyst entry or from the integrated databases, and incrementally infers high-level operational system attributes. The ASTA knowledge base is comprised of hundreds of radar facts, fundamental properties, and heuristic rules used by the rule-based inference engine. The basic inference capability is augmented by many information management tools including a graphical explanation system. ASTA employs a graphical, window-based user interface designed to present radar information in a form familiar to radar analysts.

ETL-0571 **AD A239 718**

COOPERATIVE AUTONOMOUS AGENTS TESTBED
FIRST ANNUAL REPORT
August 1990

Charles Dolan
David Payton
Karel Zikan

Hughes Research Laboratories **DACA76-89-C-0002**

Keywords: Planning, Autonomous Agents, Transportation Planning

Efforts during the first year of the contract were concentrated on developing a mathematical formalism for resupply planning. The formalism not only allows efficient plans to be constructed, but also allows those plans to be internalized plans (i.e., flexible plans). Internalized plans allow re-supply agents to be opportunistic in a changing environment. The formalism is based on expressing the re-supply problem as a flow of commodities on a graph. An economic analogy allows the re-supply agents to act as if they were self-serving agents while still accomplishing the global goals.

ETL-0572 **AD A238 570**

VISION-BASED NAVIGATION AND PARALLEL COMPUTING
SECOND ANNUAL REPORT
August 1990

Larry S. Davis
Daniel DeMenthon
Thor Bestul

University of Maryland **DACA76-88-C-0008**

Keywords: Autonomous Navigation, Artificial Intelligence, Computer Vision, Search, Parallel Processing

This report summarizes the research performed during the period May 1989 through May 1990, the first year of the contract period. The focus of the research program is visual navigation, with an emphasis on the use of massively parallel algorithms to support basic navigational tasks in vision and planning. The first section describes research performed on a project called RAMBO. (RAMBO is an acronym for Robot Acting on Moving BOdies). The project attempts to develop and integrate Connection Machine algorithms for low-level vision, intermediate level vision and visual planning to allow a mobile robot to pursue (in simulation) a moving three dimensional target through space in order to maintain visual contact with points on the surface of the target. The next section describes our past year's work on cross-country navigation. We first describe massively parallel algorithms for route planning in digital terrain maps. Then we describe our research on the problem, and present new methods. The last section presents brief descriptions of other research projects whose results were reported under this contract during the past year.

ETL-0573 AD A239 496

HYPERSPECTRAL SIGNATURES (400 to 2500 nm) OF VEGETATION, MINERALS, SOILS, ROCKS, AND CULTURAL FEATURES: I. LABORATORY AND FIELD MEASUREMENTS

December 1990

Melvin B. Satterwhite
J. Ponder Henley

Keywords: Reflectance, Hyperspectral, Spectra, Vegetation, Soil Rocks, Catalog, Spectroradiometric, Arid, Semiarid

The objective of this catalog was to document the visible near-infrared reflectance spectra (400-2500 nm) of vegetation, soils, rocks, and man-made materials, and to provide information about their unique physical and chemical properties. Spectra were taken of representative samples of a particular plant species of soil type and selected conditions so that a specific feature could be evaluated. Seasonal differences in vegetation spectra were measured for tree, shrub, herbaceous, and grass species. Soils having different textures and moisture potentials were measured. These spectra summarize results of ongoing research in different environments, although many of the field spectra were taken in semiarid and arid environments.

ETL-0574 AD B156 709L

AUTOMATED SAR CHANGE DETECTION FOR COMBAT SUPPORT PHASE I (U)

December 1990

Tim Patterson

Advanced Decision Systems (ADS) DACA76-90-C-0012

Keywords: Synthetic Aperture Radar (SAR), Morphological Filtering, Image Registration, Change Detection

The objective of this project is to design and develop a computer system for automatic change detection using synthetic aperture radar (SAR) to support the timely collection of tactical battlefield intelligence. The system will also report significant changes in the terrain with an emphasis on obstructions to vehicle movement. This Phase I effort has built a breadboard change detection system that has been tested on operational battlefield imagery. Preliminary test results show improvement over current vehicle detection techniques by more than an order of magnitude.

ETL-0576 AD A231 413

WHAT IS A HILL? AN ANALYSIS OF THE MEANING OF GENERIC TOPOGRAPHIC TERMS
January 1991

Robert R. Hoffman

Keywords: Aerial Photo Interpretation, Psychology of Perception, Artificial Intelligence, Terrain Description

This report is part of the effort to generate artificial intelligence systems for aerial photo interpretation. Such a system requires symbolic definitions of generic topographic terms, especially if the system is to interact with a human operator. The author analyzes the meanings of terms such as "hill," "plain," and "terrace," and adjectival descriptors such as "blocky," "rugged," and "large." A review of literature on topography, geomorphology, and terrain analysis reveals that generic topographic terms occur frequently in descriptions of terrain, especially those intended to communicate the perceptual form of terrain. Yet such concepts--rooted in perception, judgement, and experience--are rarely defined. A terrain analysis data base of over 1,000 propositions about the knowledge of expert aerial photo interpreters was analyzed to extract and categorize approximately 100 generic terms and 250 generic descriptors. The author's approach to defining these terms is based on concepts from ecological optics and the psychology of perception. The definitions themselves are built on concepts from the literature of terrain analysis and topography. This study has implications for practicing terrain analysts and aerial photo interpreters, as well as for the field of artificial intelligence. It suggests some new methods for describing terrain and some clarifications of traditional terminology.

ETL-0577 AD B157 337L

ADRIES PROTOTYPE SYSTEM DEVELOPMENT PROGRAM (1986-1990)
June 1990

Gil Ettinger Rick Chester Tom Shaffer
Tod Levitt Tom Esselman Mike Black

Advanced Decision Systems DACA76-86-C-0010

Keywords: Synthetic Aperture Radar (SAR), Signal Processing, Knowledge-Based Systems, Artificial Intelligence, Parallel Computer Processing, Distributed Computer Processing

The Advanced Digital Radar Imagery Exploitation System (ADRIES) program has undertaken the design and development of automated techniques to aid in the interpretation and analysis of multiple resolution synthetic aperture radar (SAR) imagery of military land scenes. This report summarizzes thee accomplishments achieved during the four years of the program. The program sulminated in the devgelopment of the Intelligent Tactical Screener (INTACTS) system, and end-to-end image exploitation prototype system that integrates conteextual and terrain reasoning to identify complex military forces in viewed scences. It is the first system to define means of using and combining multiple knowledge sources supporting image exploitation in a uniform and coherent paradigm that achieves high efficiency and accuracy through a hierarchical reasoning process.

ETL-0578 AD B157 116L

ADVANCED DIGITAL RADAR IMAGERY EXPLOITATION SYSTEM (ADRIES) ANNUAL REPORT November 1990

Science Applications International Corporation

Keywords: Synthetic Aperture Radar, Artificial Intelligence, Signal Processing, Parallel Computer Processing, Knowledge-Based Systems, Distributed Computer Processing

The ADRIES program is a three-year, multiple contractor research effort aimed at the development and demonstration of technology to support the automation of tasks required to effectively exploit multiple resolution digital radar imagery. The research focuses on techniques for exploiting Advanced Synthetic Aperture Radar (ASARS) imagery. ADRIES has three major objectives: First, to develop technology in support of automating the image exploitation process. This objective is not limited to image processing, but includes knowledge engineering, distributed processing, and other applicable areas. Second, to develop the Sensor National Testbed (SNTB). The SNTB is a collection of sequential and parallel computer architectures, and associated software, providing a research environment for exploring parallel processing for image understanding. Third, to demonstrate the applicability of the ADRIES program to a real world problem. This final report describes only the latest version of the SAIC contribution to the ADRIES software/hardware system. These contributions include: Spot Mode Detection, Other Source Analysis, Region Database, Image Database, Communication and System Services, and the Executive Controller software components. During this second year, the work at SAIC dell into three general areas: software and integration support for the INTACTS demonstration; continued development of the SNTB; and test and evaluation planning on the completed INTACTS system.

ETL-0579 AD B157 335L

ADVANCED DIGITAL RADAR IMAGERY EXPLOITATION SYSTEM (ADRIES) FINAL REPORT (1986-1990) December 1990

Science Applications International Corporation

Keywords: Synthetic Aperture Radar, Artificial Intelligence, Signal Processing, Parallel Computer Processing, Knowledge-Based Systems, Distributed Computer Processing

The ADRIES program is a three-year, multiple contractor research effort aimed at the development and demonstration of technology to support the automation of tasks to effectively exploit multiple resolution digital radar imagery. The research focuses on techniques for exploiting Advanced Synthetic Aperture Radar (ASARS) imagery. ADRIES has three major objectives: First, to develop technology in support of automating the image processing exploitation process. This objective is not limited to image processing, but includes knowledge engineering, distributed processing, and other applicable areas. Second, to develop the Sensor National Testbed (SNTB). The SNTB is a collection of sequential and parallel computer architectures, and associated software, providing a research environment for exploring parallel processing for image understanding. Third, to demonstrate the applicability of the ADRIES program to a real world problem. This final report describes only the latest version of the SAIC contribution to the ADRIES software/hardware system. These contributions include: Spot Mode Detection, Other Source Analysis, Region Database, Image Database, Communication and System Services, and the Executive Controller software components.

ETL-0580 AD A238 571

ROBUST IMAGE UNDERSTANDING - TECHNIQUES AND APPLICATIONS - FIRST ANNUAL REPORT
December 1990

Azriel Rosenfeld

University of Maryland DACA76-89-C-0019

Keywords: Image Understanding, Navigation, Vision, Edge Detection, Path Planning

The research on the contract dealt with image understanding applications to both navigation and recognition. Thirteen technical reports were issued on the contract during this period referred to by numbers in brackets in the remainder of the report. Research on navigation was concerned with the following specific topics which are discussed in further detail in this report: (a) analysis of superimposed moving patterns [1,2]; (b) path and motion planning [5,13]; (c) structure from motion [6]; (d) motion uncertainty [8]; (e) motion illusions [11]; and (f) motion recovery in the presence of discontinuities [12]. Recognition research was concerned with: (g) recognition of compact shapes by energy function minimization [3]; (h) learning of invariant shape properties [4]; (i) slant-insensitive shape descriptors [7]; and (j) edge detection [9] and line fitting [10].

ETL-0581 AD A238 678

PERCEPTION FOR OUTDOOR NAVIGATION
FIRST YEAR REPORT
December 1990

Charles Thorpe
Takeo Kanade

Carnegie Mellon University DACA76-89-C-0014

Keywords: Autonomous Navigation, 3-D Perception, Road Following, Obstacle Detection, Terrain Modeling

Research supported by this contract includes perception for road following, terrain mapping for off-road navigation, and systems software for building integrated mobile robots. We overview our efforts for the year, and list our publications and personnel, then provide further detail on several of our sub-projects. During the past year, this contract has supported research on color vision for road following; 3-D perception for terrain mapping and cross-country mobility; and system building for autonomous navigation. We have demonstrated autonomous navigation on a variety of roads, including single lane dirt, gravel, and paved; and multi-lane roads with and without lane markings. Our perception modules use a variety of techniques for video processing (clustering theory, symbolic feature detection, neural nets), and for range data analysis (landmark navigation, reflectance processing). We have also integrated position-based navigation (JNS and GPS), and combinations of all these techniques into mobile robot systems and demonstrations. Our scientific papers this year include a book (Vision and Navigation: the CMU Navlab), three PhD dissertations, and an MS thesis.

ETL-0582 AD B156 491L

KNOWLEDGE-BASED VISION TECHNIQUES FOR THE AUTONOMOUS LAND VEHICLE PROGRAM - FOURTH ANNUAL REPORT
December 1990

Martin A. Fischler
Robert C. Bolles

SRI International DACA76-85-C-0004

The goal of this research is to develop techniques for automatically acquiring and representing knowledge about complex cultural and natural environments for such purposes as intelligence analysis, planning, navigation, and manipulation. Our research strategy is to (1) develop representations and techniques for storing (or incrementally learning) semantic and geographic information about a specific geographic areas to permit both mission planning and knowledge-based interpretation of sensed data, (2) develop representations for natural and manmade objects, (3) develop techniques to predict distinctive features of these objects that can be used to identify them, and (4) develop techniques for building three-dimensional descriptions of an environment from data gathered by range or intensity sensors moving through this environment. In this report we describe our progress and plans in these areas.

ETL-0583 AD A238 681

A COMPARISON OF SOILS FROM TWENTYNINE PALMS, CALIFORNIA AND SAUDI ARABIA
January 1991

Judy Ehlen
J. Ponder Henley

Keywords: Soils: Twentynine Palms, CA and eastern Saudi Arabia, Sieve Analysis, Soil Moisture, Spectral Reflectance, Soil Color

Soil samples collected at Twentynine Palms, California, and eastern Saudi Arabia were analyzed for particle size distribution, moisture content, spectral reflectance characteristics and soil color. The results of the comparison show that, overall, the Twentynine Palms samples are finer grained than the eastern Saudi Arabian samples. Soil moisture in both sets of samples is low. The samples from eastern Saudi Arabia contain quantities of calcite and gypsum not found in the Twentynine Palms samples. The spectral reflectance of the soils from eastern Saudi Arabia is overall higher than that for the Twentynine Palms soils, and shows variations in infrared reflectance due to chemical differences that are not seen in the Twentynine Palms soils.

ETL-0584 **AD A237 105**

AN AUTOMATED SOFTWARE SYSTEM FOR UPDATING DIGITAL TERRAIN DATABASES FROM ALL-SOURCE IMAGERY, PHASE I SBIR
February 1991

J. Curlander A. Stocker
W. Kober J. Thomas

Vexcel Corporation Space Computer Corporation **DACA76-90-C-0013**

VEXCEL Corporation's Phase I SBIR research effort for ETL concentrated on the feasibility of creating the primary tools for the prototype development in Phase II of a digital change detection work station. This system in intended to be capable of detecting long-term (6 months to 1 year) and/or seasonal changes from all-source imagery. The system is intended to be hosted on a SUN-4 platform operating under a UNIX/C software environment. The emphasis of the present Phase I effort was on the two major technical challenges for the development of such a system: precision image registration and robust change detection and analysis. Most of this effort was directed toward automated SAR-optical image registration and automated change cuing experiments. Change cuing is an initial step in change detection for identifying regions where possible change events may have occurred. The automated registration and cuing efforts were successful over the data sets tested. The data sets did not contain appreciable terrain-induced distortions. Theoretical improvements for algorithms are recommended for addressing such terrain-induced registration complications in Phase II.

ETL-0585 **AD B155 495L**

NEURAL NETWORKS FOR OBJECT DETECTION USING ALL-SOURCE IMAGERY
February 1991

David Lavine
Srinivasan Rahavan
Naresh C. Gupta
Barbara A. Lambird

LNK Corporation

Keywords: Multi-Sensor Fusion, Image Analysis, Neural Networks, Gabor Transform, Automated Feature Extraction

Fusion of information from multiple sources is a key ingredient in many decision-making processes. This fusion often benefits from hierarchical decision-making which analyzed the data at various levels of abstraction. This report describes a system for performing fusion with a hierarchy of neural networks to provide this abstraction capability. The fusion system is demonstrated by extracting natural and man-made features from synthetic aperture radar (SAR) and optical imagery. The system is designed to be extensible to a much wider range of feature types and to other types of input data, including data from other types of sensors and collateral data. The uniqueness of the sensor fusion system lies in the efficient use of appropriately tailored neural networks, combining different paradigms to perform different tasks.

ETL-0586 AD A239 370

NEW METHODS OF CHANGE DETECTION USING MULTISPECTRAL DATA
May 1991

Charles Sheffield
Gil Richardson

Earth Satellite Corporation

This report discusses the final phase of a project to develop multispectral change detection methods with emphasis on human activities. Two new algorithms were developed and tested: a Spectral/Spatial Classifier and a Feature Vector Spectral Classifier. The Spectral/Spatial method appears to be a powerful new tool. The Feature Vector results were inconclusive.

ETL-0587 AD A240 455

THERMAL INFRARED SPECTRA OF NATURAL AND MAN-MADE MATERIALS: IMPLICATIONS FOR REMOTE SENSING

John Eastes

Keywords: Thermal Infrared Spectra, Spectra of Natural Materials, Spectra of Manmade Materials, Remote Sensing

This report is a compilation of laboratory thermal infrared reflectance spectra recorded over various spectral ranges between 4000 and 400 cm $^{(-1)}$ (2.5 - 25.0 micrometers) for natural and manmade materials of potential interest to both military and civilian sectors. Knowledge of the position and shape of significant spectral features as detected by remote spectrometers or spectral radiometers is necessary to discriminate between targets on the basis of either spectral emittance or reflectance. Many of the samples in this study display spectral features in either, or both of the 3- to 5- micrometer or the 8- to 14- micrometer regions of the spectrum in which terrestrial remote sensing is possible. Such information can be used to devise image enhancement strategies for data in hand or to design new instruments or experiments utilizing thermal multispectral data.

ETL-0588 AD A244 855

REMOTE SENSING FIELD GUIDE - DESERT
September 1991

The Desert Processes Working Group:
Jack N. Rinker
Carol S. Breed
John F. McCauley (Emeritus)
Phyllis A. Corl

Keywords: In support of military operations, Army terrain analysts are frequently required to provide terrain information about an area, and to do so quickly. Examples of needed information include: location of engineering materials, potential ground water drilling sites, influence of the terrain on cross-country movement, potential for dust generation, potential for cover and concealment, and sites suitable for ambush and defilade. The task is not easy because of the lack of sources for detailed and reliable information. Such information is not yet available in data bases, nor in existing maps, and neither can it be obtained by computer analysis of digital imagery. It can, however, be derived by the manual, or "eyeball," evaluation of image patterns. Although airborne or satellite imagery is now available for most of the world, the translation of these image patterns into forms usable by the terrain analysts has not been done. To bridge this gap, for at least one climatic zone, the Desert Processes Working Group has developed this Remote Sensing Field Guide directed towards desert operations. Although developed for military uses, this guide can serve all who travel and work in desert regions.

ETL-0589 AD A240 454

A HYBRID METHODOLOGY FOR DETECTING CARTOGRAPHICALLY SIGNIFICANT FEATURES USING LANDSAT TM IMAGERY
September 1991

Robert S. Rand

Keywords: A general Change Detection (CD) methodology is investigated that involves a hybrid mix of image processing, spectral transformation, and statistical pattern recognition techniques. The Hybrid Methodology attempts to combine various forms of supporting and conflicting evidence for change into a resulting change map. The approach involves differencing registered multiband scene pairs that have undergone a spectral transformation, generating threshold masks, and applying a classifier to the masked multiband scene pairs.

ETL-0590 AD A240 453

MULTISPECTRAL IMAGE MAPS FROM LANDSAT THEMATIC MAPPER DATA

September 1991

Robert S. Rand
John E. Anderson
Donald A. Davis

Keywords: This report describes a capability to produce prototype 1:50,000 scale multispectral image maps using Landsat TM data. These image maps are in the standard UTM projection, contain imbedded 1,000 meter grid lines with labeled UTM coordinates, and can easily be used in conjunction with conventional military maps of the same scale. Annotation that gives the title of the standard DMA map of the area, the Landsat TM band combinations, as well as a bar scale and compass were also imbedded into the product.

ETL-SR-4 AD B157 293L

U.S. ARMY AVIATION DIGITAL TOPOGRAPHIC DATA REQUIREMENTS FORECAST May 1989

W. Craig Dubishar
Christian P. Moscoso

Keywords: Digital Terrain Data (DTD), Army Aviation, Data Requirements Forecast, Helicopters

This forecast consolidates information on the Digital Terrain Data requirements of the U.S. Army aviation community, assesses and analyzes the requirements, and identifies emerging issues. Special Operations Aircraft (SOA) is the primary near-term user of DTD, but the LHX program and simulation efforts will be the drivers for future requirements. It is anticipated that the majority of DTD manipulation and use will occur at the Ground Mission Planning System (GMPS), although DTD will also be used operationally for navigation and map display. Existing and planned DTD products from the Defense Mapping Agency (DMA) will satisfy the majority of aviation requirements. However, the aviation community has a need for additional Vertical Obstruction Data (VOD).

ETL-SR-5

AD B157 299L
Appendix A AD B157 300L
Appendix B AD B157 301L
Appendix C-I AD B157 302L

PHASE I TACTICAL TERRAIN DATA (TTD) PROTOTYPE EVALUATION

Jeffrey A. Messmore
Louis A. Fatale

Keywords: Digital Terrain Data, TTD Prototype, Terrain Analysis, Digital Topographic Data, ISO 8211, MiniTopo

This report documents the results of DoD's Phase 1 Tactical Terrain Data (TTD) Prototype Evaluation. The concept of Tactical Terrain Data as the data base to support joint land combat evolved from an initial Army requirement for digital topographic data (DTD) forwarded to DMA in October 1984. The evaluation community consisted of the respective Army, Navy and Air Force laboratories; the U.S. Army Engineer Topographic Laboratories (USAETL), the Naval Ocean Research and Development Activity (NORDA), and the Rome Air Development Center (RADC), as well as many tactical, test, training, and simulation systems and programs. The key aspects of the data set that were evaluated were: accuracy, resolution, content, and data structure. The report presents a set of conclusions and makes recommendations to the Defense Mapping Agency concerning the future direction of TTD production.

ETL-SR-6 AD B155 087L

DIGITAL TERRAIN ELEVATION DATA RESOLUTION AND REQUIREMENTS STUDY - INTERIM REPORT
November 1990

James R. Ackeret

Keywords: Digital Terrain Elevation Data (DTED), Digital Terrain Data (DTD) requirements, Computer Image Generation (CIG), Resolution, Terrain Visualization, Terrain Classification, Threat Analysis, Line of Sight (LOS)

The DTED resolution requirement has been a controversial subject for many years among users of U.S. Army battlefield and simulator systems. The controversy has focused on the higher cost of producing high resolution DTED and the additional time required to produce a world-wide database at this resolution. The purpose of this study is to report the influence of DTED resolution on various terrain elevation applications. TRADOC Analysis Command, White Sands Missile Range, (TRAC-WSMR), also participated in this study by conducting an in-depth threat analysis. This interim report documents the results of the USAETL DTED resolution analysis and the TRAC-WSMR threat analysis for the determination of the most desirable DTED resolution for various Army tactical and simulation applications.

ETL-SR-7 AD A239 139

PDEF: A STANDARD FILE FORMAT FOR DATA INTERCHANGE
January 1991

Michael M. McDonnell

Keywords: Geographic Information System, Data Interchange, Spatial Data Storage, Data Exchange, Reformatting

This report explains a new method of encoding data in a set of files that allows advantages over current formats and methods. A new format is necessary because all current widely-available file formats retain restrictions (such as fixed field lengths) that are no longer necessary with modern programming languages. In particular, the ability to be parsed by FORTRAN programs was formerly an important requirements. The limitations of FORTRAN lead to file formats that are clumsy and difficult to work with. The proposed format has a simple syntax and flexible semantics. The format is efficient both for computers and people. It is efficient for computers because it makes use of the powerful parsing tools available for the C programming language. It is efficient for people because data descriptions are in a human-readable form and the content of a data file can be understood without a user's manual. The bulk of this report is in appendixes which give illustrative examples. Examples are presented for raster, quadtree, and vector data formats since these formats are especially prevalent in spatial data systems, a specialty of the U.S. Army Engineer Topographic Laboratories. PDEF stands for Protean Data Exchange Format.

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CORPORATE AUTHORS

PERSONAL AUTHORS

AD Numbers

APPENDIX — TITLES

1953 - 1991

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Accuracy of Cartometric Data	AD 810 496	1966
Accurate Emphemeris Time Determination and Geocentric Stations Position from Photographs of the Moon Against Stellar Background	ETL-RN-72-4	1972
Acousto-Optic Technology for Topographic Feature Extraction and Image Analysis	ETL-0256	1981
Adjunct Development Test II (DT II) of Position and Azimuth Determining System AN/USQ-70	ETL-0217	1980
Acquisition and Evaluation of Thermal Standard Data	ETL-0218	1980
ADRIES Prototype System Development Program (1986-1990)	ETL-0577	1990
Advanced Continuous Tone Plate and Process Compatible with Present Military Lithographic Reproduction Equipment and Practices	ETL-0056	1975
Advanced Digital Radar Imagery Exploitation Robust System (ADRIES) Annual Report	ETL-0578	1990
Advanced Digital Radar Imagery Exploitation System (ADRIES) Final Report (1986-1990)	ETL-0579	1990
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Advanced Development Prototype (ADP) for the Quick Response Multicolor Printer (QRMP)	ETL-0392	1987
Advanced Feature Symbolization for Three Dimensional Views	ETL-0223	1980
Advanced Methods for the Calibration of Metric Cameras	AD 706 870	1968
Advanced Radar Topographic Application	ETL-CR-73-2	1973
Advanced Satellite Hardware/Software System Study	ETL-0225	1980
Advanced Satellite Tracking Instrumentation Study	AD 882 2546	1968
Advanced Study of a Position and Azimuth Determining System (Final)	AD 844 930L	1968
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Advanced Techniques for the Reduction of Geodetic SECOR Observation (Final)	AD 640 238	1966
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Aerial Triangulation by Least Squares, Final Report	AD 140 062	1957
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Airborne Positioning and Attitude Data Application Study, Phase I	AD 815 525L	1967
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Air Photo Analysis, Photo Interpretation Logic, and Feature Extraction	ETL-0329	1984
Algorithms for Digital Terrain Data Modeling	ETL-0302	1982
All-Weather Mapping Contour Plotting Program		1965
Alternative Theories of Inference in Expert Systems for Image Analysis	ETL-0382	1985
Altimeter, Surveying, 4500 Meters, 2-Meter Divisions	1350-TR	1954
Analog Graphic Processing for 3-D Terrain Displays, Profiles, and Elevation Layer Tints	ETL-0026	1975
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Analysis and Development of Digital Mapping System Software	ETL-CR-74-5	1974
Analysis and Development of Image Statistics and Redundancy Removal	ETL-0239	1980
Analysis and Simulation of Discrete Digital Image Matching	ETL-0278	1981
Analysis and Test Results of a Gyrocompass With Reduced Susceptibility to Shock, Vibration, and Motion	ETL-0501	1988
Analysis and Tests of Environmental Effects on Gyrocompassing Accuracy	ETL-0378	1984
Analysis of Air Photo and Radar Imagery of Barro Colorado Island, Panama, An	ETL-0540	1989
Analysis of a Relaxation Scheme to Improve Terrain Elevation Data, An	ETL-0298	1982
Analysis of Edge Detection Algorithms on DIAL	ETL-0371	1985
Analysis of GEOS PC-1000 and SECOR Data	AD 882 165L	1967
Analysis of Interactive Image Cleansing Via Raster-Processing Techniques	ETL-0347	1983
Analysis of LANDSAT Systems for Cartographic and Terrain Information (Report No. 9 in the ETL Series on Remote Sensing)	ETL-0103	1977
Analysis of Multispectral Scanner Data for Location of Sand and Gravel Deposits	AD 705 673	1970
Analysis of Radar Calibration Data (Final)	AD 827 858L	1967
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Analysis of SECOR Data — Vol. I	AD 865 488L	1968
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Analysis of the Max-Min Texture Measure, An	ETL-0280	1982
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Apparent Temperature and Emissivity of Natural Surfaces at Microwave Frequencies	AD 872 878L	1970
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Application of a Feature Selection Technique to Samples of High Resolution Synthetic Aperture Radar Imagery	ETL-0330	1983
Application of a Phase Comparison Radiolocation System to Distance and Position Measurement over Mountainous and Desert Terrain		1957
Application of Artificial Intelligence to Radar Image Understanding	ETL-0387	1985
Application of Biorthogonal Filter Functions to Pattern Recognition and Feature Extraction	ETL-0222	1980
Application of Coriolis Force to Geodetic Measurements	AD 477 136	1965
Application of Hierarchical Data Structures to Geographical Information Systems	ETL-0301	1982
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Application of Inertial Techniques to Surveying	AD 805 156	1966
Application of Image Sensing Arrays to Metrology, Detection and Instrumentation	ETL-CR-71-6	1970
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Approach to Model Formation Based on Formal Geometric Reasoning, An	ETL-0493	1988
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Army Terrain Information System	ETL-0050	1976
Artifact Removal in Frequency Domain Compressed Imagery	ETL-0233	1980
Artillery Survey System, Phase 1 — Study of Methods	AD 883 288L	1958
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Assessment of Means for Determining Deflection of the Vertical	ETL-0303	1982
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Astronomical Attachment Azimuth Determination, Reflecting, for Transit or Theodolite	1374-TR	1954
ATF-Hadego Photocompositor Photolettering Machine	1414-TR	1955
Atmospheric Refraction	TR-61-505	no date
Atmospheric Refraction for Satellite Photography	56-8B-1	1962
Autocorrelation of Control Points on 11-Band Multispectral Imagery	ETL-0473	1987
Autonomous Land Vehicle (ALV) Program - Seventh Quarterly Report, The	ETL-0496	1988
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Automatic Contour Digitizer (ACD)	ETL-ETR-71-2	1971
Automatic Contouring Instrumentation	1488-TR	1957
Automatic Control of Digital Stereo Correlation Methods	ETL-0356	1984
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Automatic Line Network Extraction From Aerial Imagery of Urban Areas Through Knowledge Based Image Analysis	ETL-0568	1989
Automatic Map Compilation System	AD 277 456	1962
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Automatic Radar Feature Extraction System Using Descriptors	ETL-0533	1989
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Automation of Airborne Profile Recorder Data Reduction (Interim)	AD 805 562L	1966
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Backscattering of Electromagnetic Waves from a Slightly Rough Surface with a Lossy Layer	ETL-TR-74-10	1974
Backscattering of Electromagnetic Waves from a Surface Composed of Two Types of Surface Roughness	ETL-TR-71-4	1971
Backscattering of Radar Waves by Vegetated Terrain	ETL-0105	1977
Backscattering of Radar Waves from a Tilted, Slightly Rough Surface	ETL-0124	1977
Base Plant Correlator	ETL-CR-71-15	1971
Base Plant Correlator (Final)	ETL-CR-73-3	1973
Basic Factors Limiting the Accuracy of Mapping and Aerotriangulation by Photogrammetric Procedures	AD 77 390	1955
Bayesian Approach to Identification of a Remotely Sensed Environment	AD 860 060	1969
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Bibliography of In-House and Contract Reports	ETL-SR-70-1	1970
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Bibliography on the Chemical Weathering of Granitic Rocks, A	ETL-0505	1988
Bimodal Display	ETL-0110	197
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Camera Calibration Study		no date
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Cartographic Design Standards — A Preliminary Investigation		1967
Cartographic Drafting Methods and Equipment	1305-TR	1953
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Cartographic Electron Beam Recorder (EBR) System	ETL-0111	1977
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Characterization and Optimization of an Electro-Optic Imaging Device for Real-Time Map Profiling	ETL-CR-74-18	1974

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Characterization of the PROM for Coherent Optical Processing Applications	ETL-0053	1976
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Circularly Polarized Measurements of Radar Backscatter from Terrain	ETL-0199	1980
Circularly Polarized Measurements of Radar Backscatter from Terrain and Snow Covered Terrain	ETL-0234	1980
Circumpolar Method for Determining Azimuth	ETL-0317	1983
Classification and World Distribution of Vegetation Relative to V/STOL Aircraft Operations	ETL-SR-74-4	1973
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Classification of Metamorphic Rocks and Their Applications to Air Photo Interpretation Procedures, The	ETL-0341	1983
Classification of Selected Radar Imagery Patterns Using a Binary Tree Classifier	ETL-0442	1986
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CMU (Carnegie-Mellon University) Strategic Computing Vision Project Report: 1984 to 1985	ETL-0466	1987
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Color Contact Printer Mark III	ETL-ETR-70-9	1970
Color Ink-Jet Demonstration Program	ETL-0196	1979
Color Orthophotomaps	ETL-ETR-72-2	1972
Color Separation System Evaluation	AD 672 078	1968
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Combined Engineering and Service Tests of the Copy and Supply Van Section of the Motorized Photomapping Train	1444-TR	1956
Combined Engineering and Service Tests of the Map Revision Van Section of the Motorized Photomapping Train	1447-TR	1956
Combined Engineering and Service Tests of the Multiplex Van Section of the Motorized Photomapping Train	1520-TR	1958

TITLE	REPORT NO.	YEAR
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Comparative Aerotriangulation Tests of the Multiplex Kelsh Plotter, Stereoplanigraph, Wild Autograph Model A-5, and Wild Stereoplotter Model A-6	1349-TR	1954
Comparative Study of Photography for Soils and Terrain Data	38-TR	1968
Comparison of Soils from Twentynine Palms, CA and Saudi Arabia, A	ETL-0583	1991
Comprehensive Summary of Project Trend	ETL-0041	1975
Computer-Assisted Likely Minesite Prediction Model and Estimated Electromagnetic and Thermal Soil Properties	ETL-0391	1985
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Computer Program to Simulate Scenario Functions	ETL-0025	1975
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Computing a Line-of-Sight Using Digital Image Matching and Analytical Photogrammetry	ETL-0027	1975
Consensus Theory in Expert Systems: An Adaptive Inference Framework and Application to Image Understanding	ETL-0524	1988
Concept Development of Automated Image Analysis	ETL-0194	1979
Concept Development of Automatic Instrumentation for Monitoring Movement of Dams	ETL-0187	1979
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CONRAD — A Program to Contour Radar Data	ETL-CR-73-20	1973
Continuous-Tone Electrophotography	AD 673 881	1968
Contour Digitizing and Tagging Software (CONTAGRID)	ETL-0228	1980
Contour-to-Grid Interpolation with Nonlinear Finite Elements: A Feasibility Study	ETL-0472	1987

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Contribution to the Philosophy of Climatic Design Limits for Army Materiel: Extreme Hot-Desert Conditions	ETL-TR-72-5	1972
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Conversion of the CALAP Program from FORTRAN to DUCK. Final Report	ETL-0419	1986
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Corona Study Relevant to Electrostatic Printing Process	ETL-CR-71-22	1971
Corps of Engineers Maintenance Package for Inertial Survey Equipment	AD 847 498	1963
Correlation of Noisy Images	ETL-0230	1980
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Cumulative Probability Tables for Testing Consensus in Ranking Experiments	ETL-0418	1986
Data Base Sizing Methodology Applied to the Army Terrain Information System (ARTINS)	ETL-0150	1978
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Description of Instrumentation Data Analysis and Reduction for an Atmospheric Seeing Monitor	AD 701 124	1969
Design and Analysis of a High-Production Mini-Computer System for Regridding Digital Terrain Elevation Matrices	ETL-0240	1980
Design and Development of a Position and Azimuth Determining System (PADS)	ETL-CR-71-18	1971
Design and Development of an Advanced Electron Beam Control System	ETL-0032	1975
Design and Development of Power Package for Surveying Instrument: Azimuth, Gyro, Lightweight	ETL-CR-71-5A	1971
Design and Development of Surveying Instrument: Azimuth, Gyro, Lightweight (SIAGL)	ETL-CR-71-5	1971
Design and Fabrication of a 70 Millimeter Interference Imaging System	ETL-CR-71-8	1971
Design and Fabrication of an Experimental Multiband Camera	ETL-CR-71-28	1971
Design and Feasibility Study of an Off-Line Digital Orthoprinter for Field Use	ETL-0149	1978
Design and Feasibility Study of HOC as a Van Mounted Stereo Model Digitizer	ETL-0109	1977
Design, Fabrication, and Test of a Position and Azimuth Determining System (PADS)	ETL-CR-73-6	1973
Design Issues in Video Disc Map Display	ETL-0362	1984
Design, Modification, Fabrication, and Test of a Prototype Miniaturized North Reference Unit (MINRU)	ETL-0276	1979
Design of a Laser Experiment for the Verification of the Inverse Scattering Theory	AD 463 012L	1965
Design of a Map Update Capability for Engineer Topographic Units	ETL-0107	1977
Design of an Experimental Program for Evaluation of LBR Systems	ETL-0182	1979
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Volume 1	AD 270 216L	1961
Volume 2	AD 270 205L	1961
Volume 3	AD 270 207L	1961
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Determination of Height Differences from Gravity and Gravity Gradients	ETL-71-CR-10	1971
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Determination of the Anomalous Gravity Potential from Satellite and Terrestrial Data Under Utilization of Modern Gravimetric Theory	ETL-RN-73-2	1973
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Developing a Data Base for Predicting Soviet Tactical Behavior	ETL-0015	1975
Development of a High Precision Capability for Monitoring Structural Movements of Locks and Dams	ETL-0121	1977
Development of an Integrated Mobile Robot System at Carnegie Mellon University	ETL-0546	1989
Development of an Integrated Mobile Robot System at Carnegie Mellon University	ETL-0565	1990
Development of a Prototype Family of Military Geographic Intelligence Products to Support Airmobile Operations	ETL-ETR-70-7	1970
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Development of Automatic Names Placement Software	ETL-0484	1987
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Development of Computer Vision Techniques for Automatic Feature Extraction	ETL-0451	1987
Development of Descriptor Sets for the Unambiguous Characterization of Geographic Features on SAR Imagery	ETL-0369	1984
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Development of Height Finder Oblique, Topographic	1383-TR	1954
Development of High Speed CRT Print Head Systems for Cartographic Applications	ETL-0213	1980
Development of Improved Area Correlation Techniques	ETL-CR-73-19	1973
Development of Lightweight Long-Range Survey System (LRSS)	AD 477 042	1965
Development of Spherical Map Sections and Transparent Conforming Overlays	1440-TR	1956
Development, Service Tests, and Production Model Tests, Autofocusing Rectifier	1307-TR	1953
Development, Test, Preparation, Delivery, and Installation of Algorithms for Optimal Adjustment of Inertial Survey Data	ETL-1307	1982
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Electrophotographic Imaging Materials Evaluation	ETL-0266	1981
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